METHODS AND OPERATIONS AT THE KAISER STEEL CORP. EAGLE MOUNTAIN IRON MINE RIVERSIDE COUNTY, CALIF.

BY R. R. TRENGOVE

* * * * * * * * * **Information Circular 7735**

MARCH 3, 1849

UNITED STATES DEPARTMENT OF THE INTERIOR
Douglas McKay, Secretary
BUREAU OF MINES
Thos. H. Miller, Acting Director

Work on manuscript completed April 1955. The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is made: "Reprinted from Bureau of Mines Information Circular 7735."

February 1956

METHODS AND OPERATIONS AT THE KAISER STEEL CORP. EAGLE MOUNTAIN IRON MINE RIVERSIDE COUNTY, CALIF.

BY

R. R. TRENGOVE[1]

CONTENTS

Page

Introduction 1
Acknowledgments 1
History 1
Ore deposits 6
  General geology 6
  Size, shape, and distribution 7
The ore 7
Methods of prospecting and exploration 8
Planning open-pit mining 9
Using the plan in the operation 9
Mining plan for North ore body and South ore body 11
Drilling 11
Blasting 13
Loading 13
Transportation 16
Cost data 16
Crushing and loading 17
Sampling 22
Railroad operation 22
Drainage, water supply, power 22
Safety organization 22

TABLES

1. Size and shape of the North Ore Body and South Ore Body.... 7
2. Operating costs of major pit operations 17
3. Wage rates of main job classification 17

---

[1] Mining engineer, Bureau of Mines, Reno, Nev.

Information Circular 7735

ILLUSTRATIONS

Fig. Page

1. Location map 2
2. Plan map of Eagle Mountain iron mine, Riverside County, Calif. 3
3. Upper location, Eagle Mountain, Calif. 4
4. Aerial view, Eagle Mountain, Calif. 5
5. Typical ore section in the North Ore Body, showing bench, berm, and slope arrangement 10
6. Bucyrus-Erie churn drill 12
7. Bucyrus-Erie 150-B electric shovel 14
8. Loading on both sides of shovel 15
9. Truck dumping into primary crusher 18
10. Primary crusher 19
11. Secondary crusher and beneficiation plant, looking west from primary crusher 20
12. View looking east toward North and South Pits; beneficiation plant in left background 21
13. Loading tower 23
14. Safety bulletin board at mine office 25

INTRODUCTION

This paper is one of a series published by the Bureau of Mines on mining methods and operation practices. It describes the open-pit mining method and operations of the Kaiser Steel Corp. Eagle Mountain iron-ore mine, which is in the extreme southeastern part of California 175 miles east of Los Angeles in Riverside County. Nearest town to the mine is Indio, which is 60 miles away by an excellent highway (fig. 1). Elevations at the deposit vary from 1,400 to 3,000 feet. Figure 2 is a plan map of the Eagle Mountain iron mine.

Kaiser Steel Corp. built a model camp at the mine, with all modern conveniences (fig. 3). The camp, comprising 145 homes, dormitories, mess hall, commissary, post office, and recreational facilities for 600 people, is at 1,390-foot elevation. The area has winter-resort weather between October and May, with occasional drops of temperature to 25° at night. From June to September temperatures sometimes rise to 120° during the day. Rainfall is scant, approximately 2 inches a year, the majority of which comes as cloudbursts during the summer months.

Iron outcrops run roughly east-west along foothills in a spur of the Eagle Mountains. This is the extreme eastern end of the iron formation that extends about 7 miles westward (fig. 4).

The property produces all the blast-furnace ore requirements for the company Fontana, Calif., steel plant. With three blast furnaces in production, about 2-1/4 million tons of iron ore will be required yearly.

ACKNOWLEDGMENTS

Acknowledgment is made to the Kaiser Steel Corp. for its assistance in preparing and publishing this information circular. Special acknowledgment is due to R. G. Heers, manager, Mining and Raw Materials; Kenneth B. Powell, superintendent, and B. A. Binckley, assistant superintendent, both of Raw Materials; M. J. Naughten, safety director; and John Bennett, safety supervisor; J. G. Hansen, mine superintendent; and W. A. Horton, pit foreman. Certain information in this report was obtained from published articles by Kenneth B. Powell[2] and George W. Huseman,[3] technical employees of the Kaiser Steel Corp.

HISTORY

The importance of the Eagle Mountain district as a potential source of iron ore on the Pacific coast was recognized early in the century by E. H. Harriman of the Southern Pacific Railroad. Over 100 claims were acquired and patented in 1908; but until the late 1930's, this area had no usable roads, water, or power. During this period far western iron-ore deposits held little commercial interest.

---

[2] Powell, K. B., Eagle Mountain Helps Kaiser Meet Growing Steel Need: AIME Min. Eng., May 1953, pp. 478-482.

[3] Huseman, G. W., Kaiser Stepping Up Production at Eagle Mountain Iron Mine: Eng. and Min. Jour., vol. 154, No. 5, May 1953, pp. 80-86.

Original from THE OHIO STATE UNIVERSITY

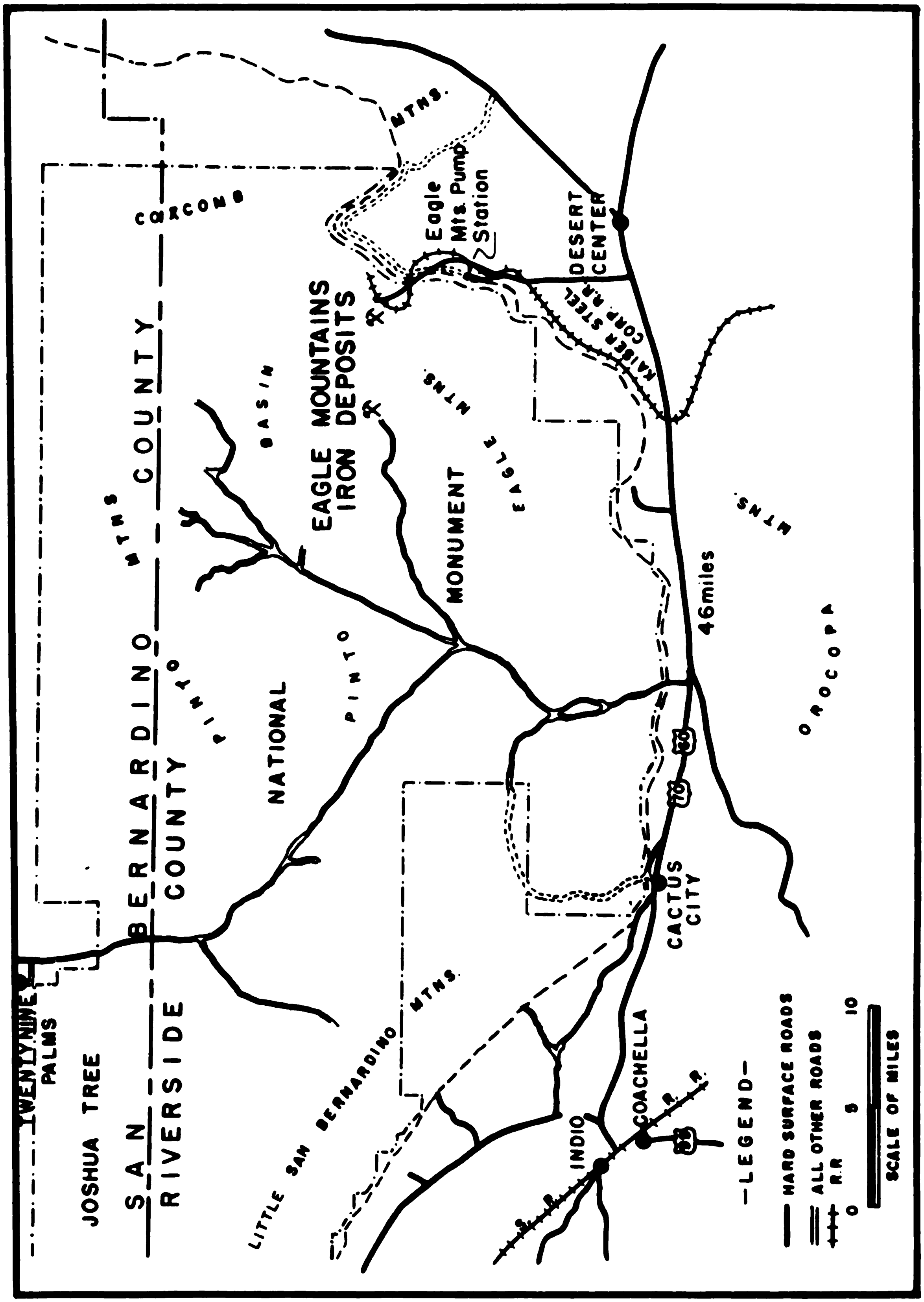


Figure 1. - Location map.

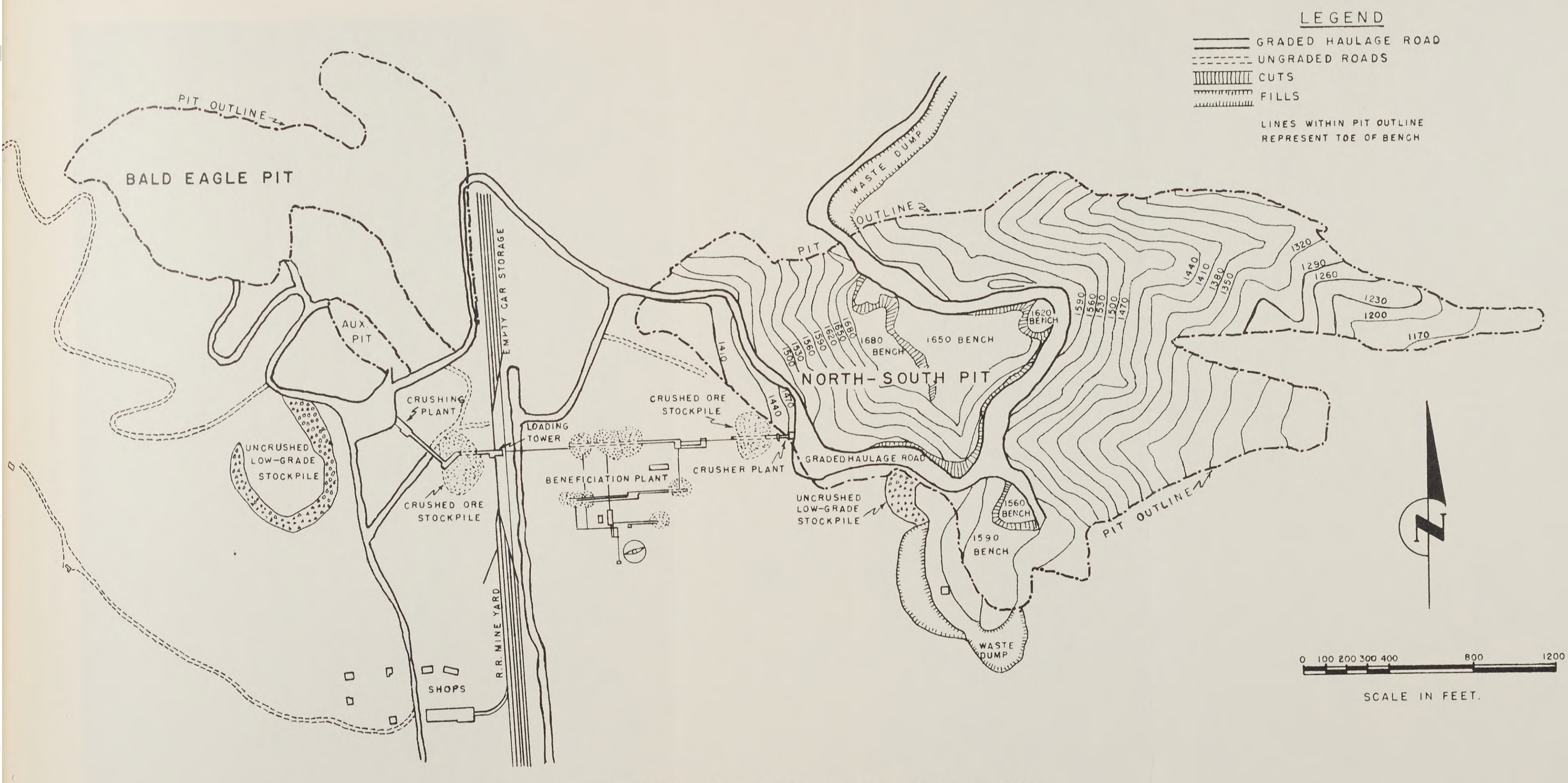


Figure 2. - Plan map of Eagle Mountain mine, Riverside County, Calif.

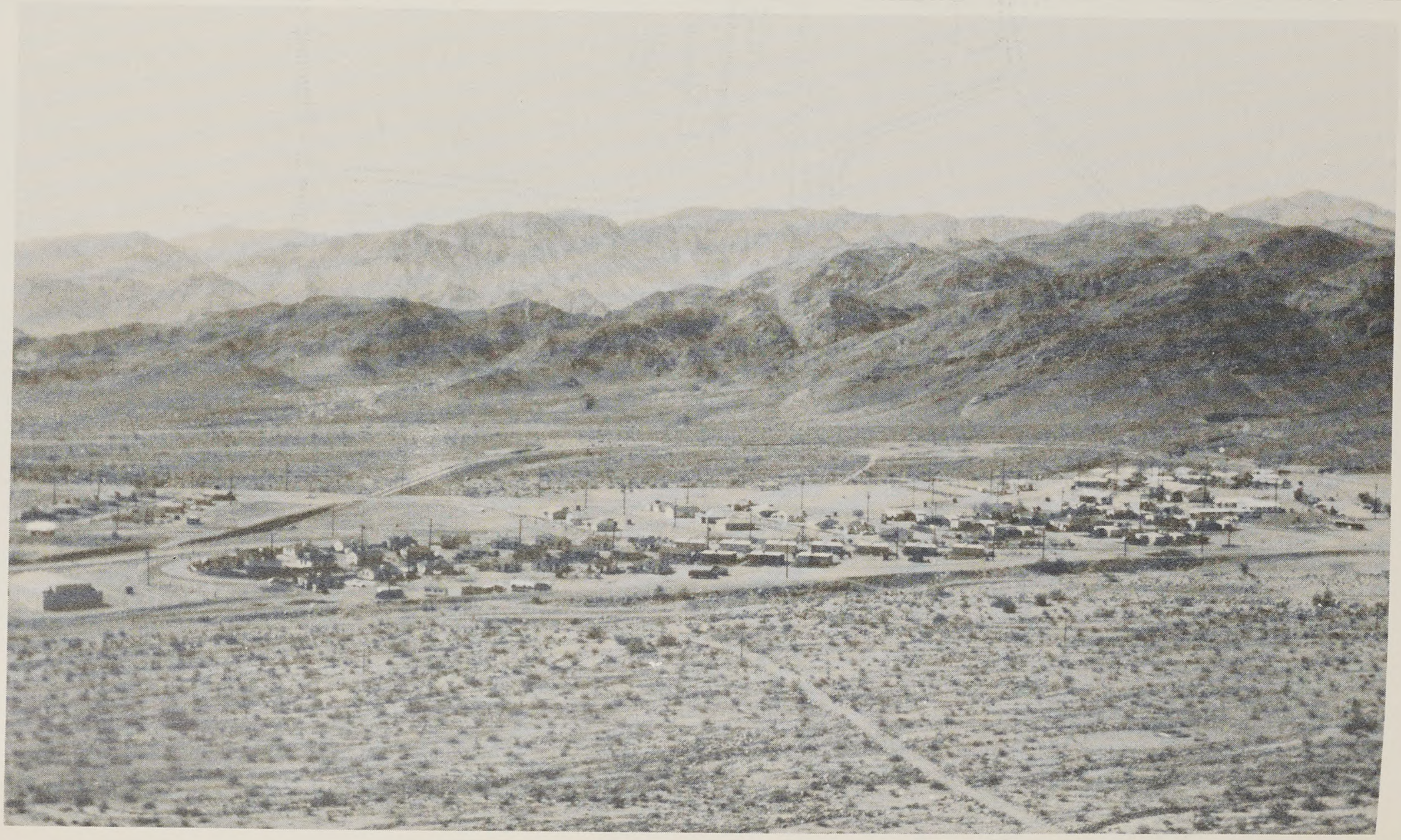


Figure 3. - Upper location, Eagle Mountain, Calif.

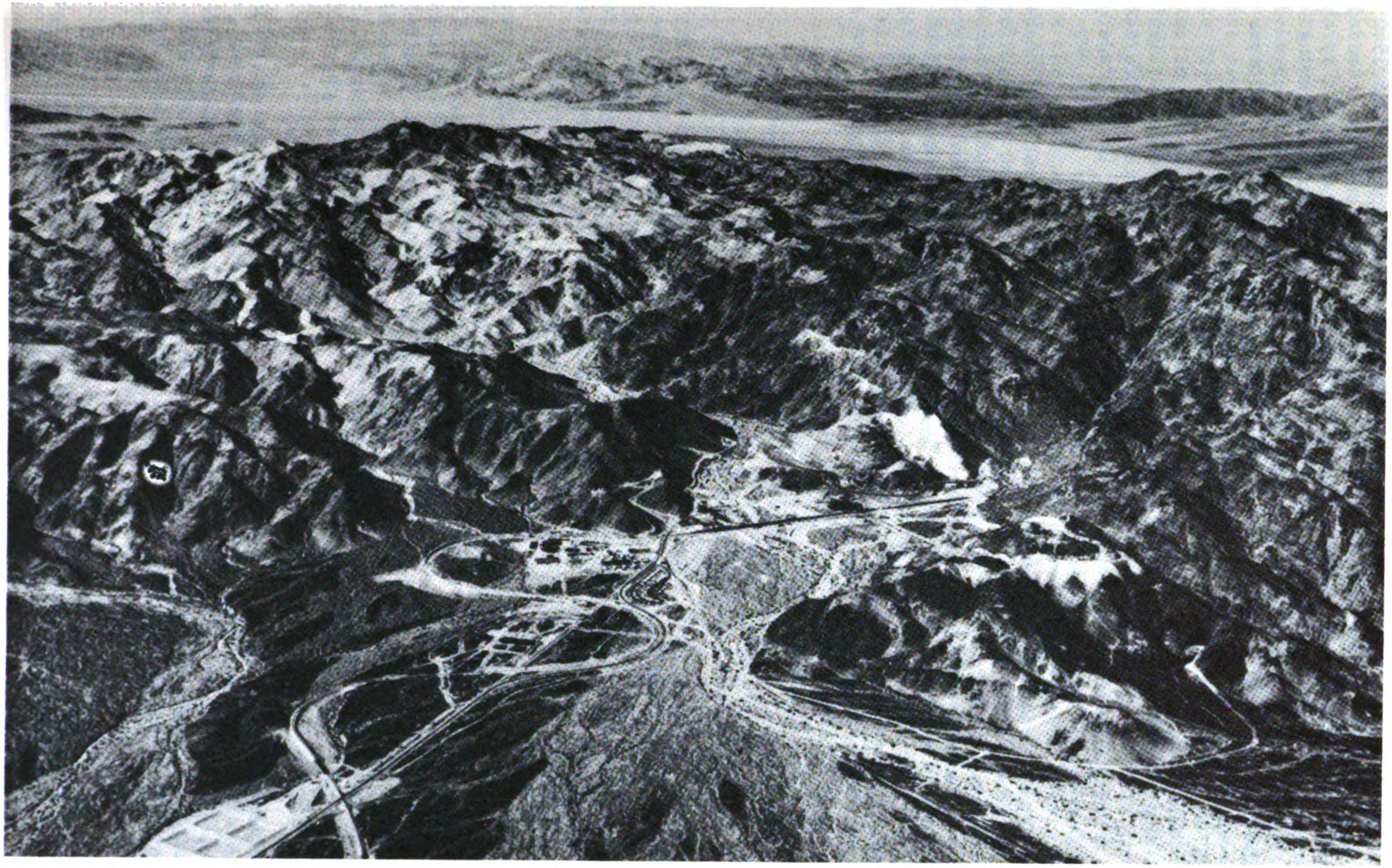


Figure 4. - Aerial view, Eagle Mountain, Calif.

The Riverside Iron & Steel Co. of Pasadena, Calif., was organized in 1940 and obtained control of the Southern Pacific Land Co. claims. The company intended to erect several electric furnaces on the property to make higher grade iron by the Knowles process, as developed by the Corby Iron & Steel Co. in England, using petroleum coke as a reducing agent. These plans had to be abandoned because of the war, and the only production during World War II was approximately 60,000 tons of crude iron ore for ship ballast and shipment to the cement industry.

Under the Strategic Minerals Program, the Bureau of Mines, in conjunction with the Federal Geological Survey, started an exploration program September 8, 1941. This was completed May 16, 1942. Project work indicated the existence of a large tonnage of direct-shipping ore and a greater potential reserve of lower grade ore amenable to low-cost beneficiation.

In 1946 Kaiser Steel Corp., which was operating 1 blast furnace and 7 open hearths using 50- to 55-percent iron ore from Cedar City, Utah, and high-sulfur ore from the Vulcan mine, Calif., acquired the property. During 1947-48, a railroad was built from the property to the Southern Pacific Railroad at Ferrum, Calif.; a crushing plant and stockpiling and loading facilities were constructed. In the latter part of 1948 opencut mining was begun on the Bald Eagle deposit, and regular shipments of iron ore were made to the Fontana steel mills 164 miles away. In 1949 a second blast furnace of 1,200 tons daily capacity was added at Fontana, and a third blast furnace of 1,200 tons daily capacity was added in 1953.

ORE DEPOSITS[4/]

General Geology

The oldest formation in the northern part of the Eagle Mountains consists of gneiss, schist, and quartzite, with local thin layers of crystalline limestone. Next younger is a thick series of metamorphic sedimentaries, the lower part of which consists of massive vitreous quartzite, with thin-bedded and schistose feldspathic layers, whereas the upper part includes crystalline dolomite, quartzite, schist, lime-silicate rock, iron ore, and various metamorphic minerals.

These sedimentaries have been intruded by sill-like bodies of quartz monzonite. The deposition of the iron ore and the associated metamorphic minerals, serpentine, mica, amphibole, epidote, and pyroxene, followed the period of plutonic activity, these minerals having been introduced by deep-seated solutions that replaced the dolomite and probably parts of the more impure quartzites. A period of uplift and tilting followed mineralization, accompanied by considerable faulting, which displaced the sediments (including the ore beds) as much as 300 feet vertically. Still later fine-grained dikes 1 to 40 feet wide were intruded, many of which cut the ore formations.

In the eastern part of the district 2 beds of ore extend east and west for about 2 miles, with an average dip of 40° N.; they are separated by 200 to 250 feet of quartzite and lime-silicate rock. The iron and associated metamorphic minerals have completely replaced the beds of dolomitic limestone in this part of the district; but farther west the ore occurs in bands or irregular masses within the dolomite, roughly following the bedding of the latter.

[4/] Bureau of Mines, Eagle Mountains Iron District, Calif.: War Min. Rept. 97, 1943, pp. 20-22.

Size, Shape, and Distribution

The principal ore deposits of the Eagle Mountains occur in the northern part of the metamorphic sedimentaries, within which two horizons of dolomitic limestone have been irregularly replaced by iron ore. These 2 beds are separated by a belt of quartzite that is 500 feet thick in places. Because of their origin, the ore bodies generally follow the natural irregularities of the replaced sediments and range from 1 to 350 feet in thickness and 25 to 3,000 feet in length. The average strike is east-west, and the average dip is 40° N. The lateral extent of the ore bodies is not sharply defined, the high-grade ore grading into serpentine-magnetite rock or impure altered quartzite and lime silicate.

One of the largest deposits in the district occurs at the east end in an area along the ore-bearing zones having a maximum width of 1,600 feet and a length of 7,500 feet. Three deposits occur in this area, the largest being in the upper, or northern, ore bed; the other two are on the east and west sides, respectively, of Bald Eagle wash in the lower or southern ore zone. These three deposits were explored by the Bureau of Mines and are now designated by the Kaiser Steel Corp. as the North Ore Body, South Ore Body, and Bald Eagle. Except for several hundred thousand tons of ore, the Bald Eagle deposit has been depleted of open-pit ore and will receive no further consideration in this report. Table 1 gives data of size and shape of the North Ore Body and the South Ore Body.

TABLE 1. - Size and shape of the North Ore Body and South Ore Body

	North Ore Body, feet	South Ore Body, feet
Strike length....................	5,200	2,600
Length explored.................	1,400	2,200
Maximum width across outcrop....	450	300
Maximum thickness normal to dip.	325	80
Average thickness normal to dip.	250	60
Average dip.....................	45	30
Depth, Bureau of Mines exploration on dip....................	500	1,200
Probable depth on dip...........	850	1,800

In the remainder of the district there are about 60 other deposits ranging in length from 150 to 1,500 feet and in maximum width of outcrop from 30 to 250 feet. Of these 27 have an outcrop of 20,000 to 100,000 square feet each, with a total area of 943,000 square feet; 4 deposits have an outcrop of over 100,000 square feet each, the total area of these being 616,000 square feet.

THE ORE

The principal iron minerals are hematite and magnetite. The former occurs as a secondary mineral after pyrite and magnetite, although some small bodies of coarsely crystalline specular hematite are of primary origin. Near the surface and in the upper 100 feet of the ore beds, hematite predominates over magnetite in the ratio of about 5:1, but at depth magnetite, generally associated with pyrite, is the predominant ore mineral.

The highest grade ore is either a hard, dense, red hematite varying in texture from coarsely crystalline to finely granular or a hard, coarsely crystalline magnetite.

The lower grades of ore are of 2 general types; 1 is a mixture of granular hematite and magnetite containing abundant disseminated silicates, and the other consists largely of magnetite in a gangue of serpentine, tremolite, and minerals of the mica and chlorite groups.

The ore in the North-South pit was divided into 2 categories, 30- to 50-percent iron (the iron content was lowered to 30 percent pending beneficiation) and plus-50-percent iron. Combined grades total 51,094,000 tons, assaying, before beneficiation, 50.7 percent Fe, 0.086 percent P, 12.18 percent SiO_2, 1.64 percent Al_2O_3, 1.87 percent CaO, 5.42 percent MgO, and 0.603 percent S. Waste to be stripped to permit extracting this ore totals 19,672,000 cubic yards. The ratio of the ore to stripping will be 1 ton of ore to 0.385 cubic yard of waste.

METHODS OF PROSPECTING AND EXPLORATION

Exploration by the Bureau of Mines comprised trenching, diamond drilling, and underground exploration by adits, shafts, and raises. The general plan was a combination of surface trenching and core drilling both on lines 200 feet apart and at right angles to the strike of the beds; the holes were so spaced and directed on these lines as to cut the ore beds at 200 and 400 feet on the dip.

Trenches averaging 2 feet in width were dug by hand across the outcrops, jackhammers with moils being used to get down to the solid ore. The bottoms of the trenches were cleaned thoroughly with compressed air before sampling. Samples weighing about 20 pounds per linear foot were then cut in 5-foot sections, crushed to pass 1/2 inch, quartered, and shipped to Lerch Bros., Hibbing, Minn., who made all analyses for the project. Drill holes were sampled in 5-foot sections unless the formation changed definitely or it became necessary to stop drilling and cement the holes in crevices or broken ground.

Ordinarily the only analyses on core and sludge samples were for iron and sulfur. Composite sludge samples were collected for each hole and analyzed for iron, sulfur, and phosphorus, and representative composite sludges for each deposit were completely analyzed.

This exploration by the Bureau of Mines, with the assistance of the Federal Geological Survey, was preliminary and not intended for close control, such as is required in drawing mining plans and supplemental drilling was necessary. This drilling explored both east and west ends along the strike. To obtain greater depth on the dip, additional drilling was done from a tunnel at a lower elevation.

Supplementing the 6,700 feet of trenching, 14,500 feet of diamond drill, and 485 feet of underground exploration by the Bureau of Mines, the Kaiser Steel Corp. completed an additional 1,000 feet of trenching, 17,000 feet of diamond drilling, and about 3,000 feet of underground exploration. The combined results of all exploration work were used in completing the current mine plans for the North Ore Body and the South Ore Body.

To aid in exploring and developing the balance of the property, an aerial survey was completed with pictures and topographic maps on a scale of 400 feet to the inch at 25-foot contour intervals.

Before the company drilled a magnetometer survey of about 3,500 setups was made. When correlated with previous drilling and geology, this work made spotting of proposed diamond-drill holes for a pit plan comparatively simple.

The underground exploration work by the company comprised 2,826 feet of tunnel to get greater depth under the main exposure, which was drilled by the Bureau of Mines. This was driven in two parts - parallel to and in the footwall of the North Ore Body; both flanks of both ore bodies were exposed on the east and west ends. Topography and formation were ideal for such work. The west entrance began at the 1,390-foot elevation and was driven 1,277 feet, and the east entrance began at the 1,250-foot elevation and was driven 1,549 feet. Headings were connected by a 153-foot raise. Diamond-drill stations were cut at 200-foot intervals, or closer where needed in geologically doubtful areas, and holes were drilled. Both ore bodies could be reached for exploring from the tunnel. Sixty holes were drilled from underground and surface stations.

PLANNING OPEN-PIT MINING

Before mining plans could be developed, a field survey was necessary to obtain all of the geological and topographic data. To obtain this information, the Kaiser Steel Corp. set up a triangulation system of primary and secondary controls. This system was tied into a carefully measured baseline on the property.

As a control for the mapping of the area over each ore deposit, a baseline was staked along the strike of the outcrop and tied in to the triangulation system. Cross-section lines were then run at 100-foot intervals at right angles to and tied in to the baseline. These cross sections were projected well beyond the foot and hanging walls of the ore body to allow for stripping limits. A survey was then made along all sections, obtaining the elevations and locations of all contacts, faults, dikes, trenches, drill holes, and surface topography. This information was plotted on plan maps and cross sections.

A mining plan was developed by working from the cross sections and then projecting the work into a horizontal mining plan (fig. 2) showing the outline of the pit, the bench elevations, grade and tonnage by benches, and cubic yards or tonnages of stripping, including waste by benches and waste disposal area adjacent to pit. On each section is drawn a tentative pit slope needed to extract the ore shown on the sections. In addition to the information plotted on the sections obtained from the surface survey and drill holes, the shape of the ore body, waste intrusions, vein splits, and fault displacements were outlined on the sections.

The pit slope on the hanging-wall side of the North Ore Body is one-half horizontal to 1 vertical, with a berm 30 feet wide added each 90 feet vertically (fig. 5). To obtain an efficient mining plan with a minimum of sharp curves, which makes for easy work and safety, some pit slopes on the sections may have to be moved either to the left or right, keeping in mind the ratio of waste to ore, the fracture zones, and the strike and dip of faults. The objective is a workable plan for safely extracting maximum ore with minimum waste. The exploration work forms a reliable mining plan for extracting ore and can be followed without change from the highest to the lowest bench. Location of the pit scarp, berms, and benches, along with other pertinent data, such as grade of ore, amount on each bench, cubic yards of stripping waste, and elevations, are all known so that work can be planned.

USING THE PLAN IN THE OPERATION

Triangulation stations, established within the pit as needed from stations outside the pit area, makes it easy for the engineers to stake out the toelines and elevations for the various benches. The toelines are spotted before the blast holes are drilled. Having a definite mining plan enables the operator to locate the

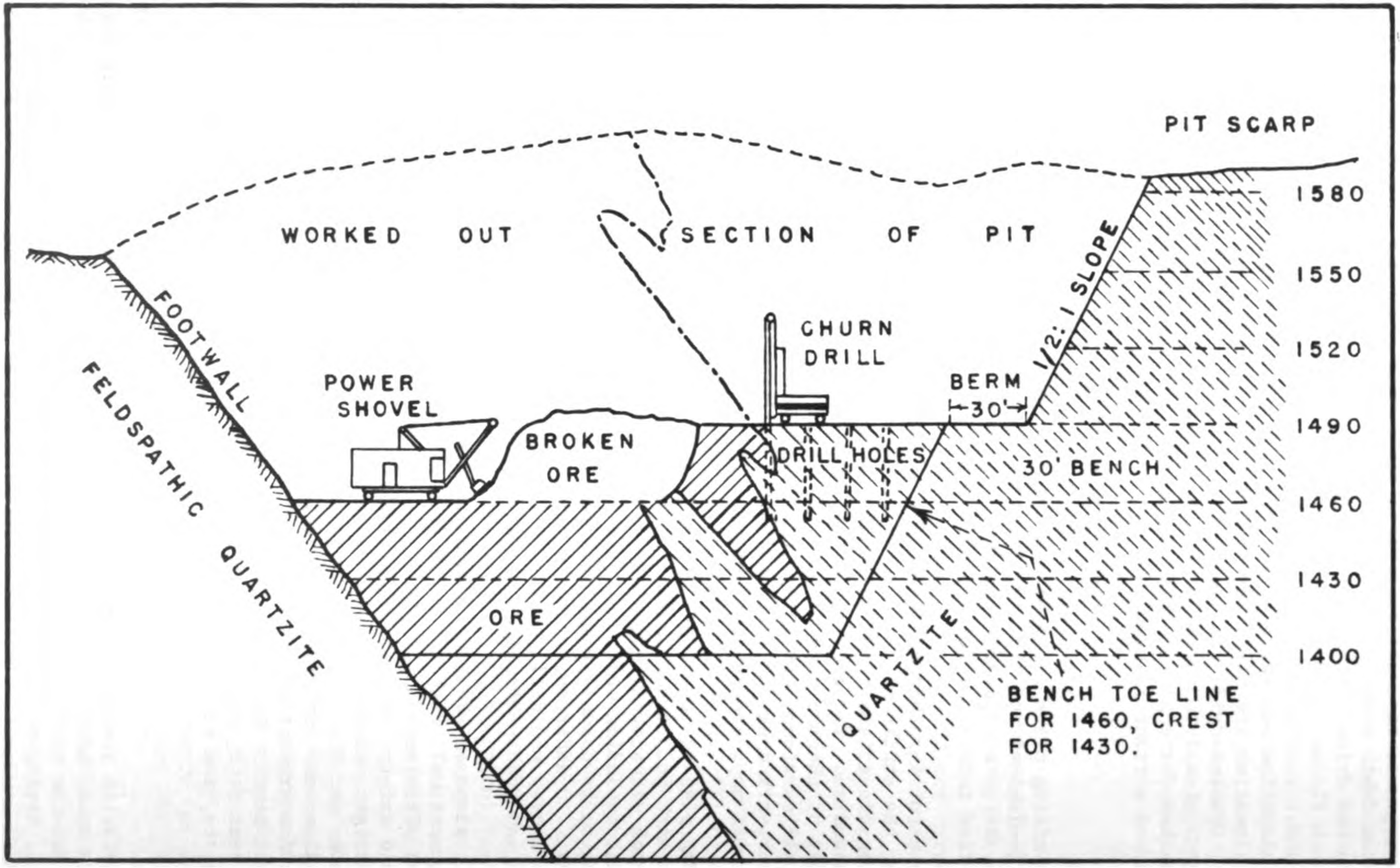


Figure 5. - Typical ore section in the North Ore Body, showing bench, berm, and slope arrangement.

Original from THE OHIO STATE UNIVERSITY

crusher to handle maximum tonnage with minimum hauling, to dispose of the waste in the most efficient manner, to mine ore, to make certain grades, and to know the ratio of ore to waste. The last is essential in determining the cost per ton of ore mined.

MINING PLAN FOR NORTH ORE BODY AND SOUTH ORE BODY

Current operations begun in 1952, are on two ore bodies known as the North Ore Body and the South Ore Body, which will be mined in one pit. The pit will be 4,600 feet long, 2,000 feet wide at the widest point, and 660 feet from the highest elevation to the pit floor. It will have 22 benches, each 30 feet high. These benches will provide for mining and stripping the two ore bodies.

A truck-haul road 70 feet wide was constructed on a 7-1/2- to 8-percent grade from the west end of the pit to the top bench elevation at 1,710 feet on the north boundary of the North-South pit (fig. 2). In laying out the haul road it was planned so that the top 10 benches would intersect the bench elevation within the pit limits. Three benches will be mined simultaneously, and work on each will be timed to the requirements of ore and the need for stripping. Work on each bench is begun at the intersection of the road and the bench elevation.

The primary crusher is set at the 1,500-foot elevation, which will permit mining over 15 million tons of ore before moving to a lower elevation. Ore is trucked down grade to the crusher, and waste is either trucked down grade to waste dumps or level across benches to the footwall dump. Length of haul for ore and waste varies from 500 feet to 2,600 feet. The ratio of ore to stripping will be 1 ton of ore to 0.385 cubic yard of waste. At present, ore is being removed from 3 benches, the 1,590, 1,620, and 1,650.

DRILLING

Primary drilling, which represents almost 100 percent of all blast-hole drilling (only 25 boulders usually blasted per 14,000 tons of ore), is done mostly with 6 Bucyrus-Erie, diesel-driven, model 42-T churn drills (fig. 6). Two smaller churn drills, Bucyrus-Erie model 29-T, are used at times. All churn-drilling machines are mounted on crawlers. The holes are collared and drilled with a 9-inch, California-type, Mother Hubbard drill bit. The 42-T churn drill uses a 30-foot stem. When it is attached to the bit the assembly weighs 5,100 pounds. Heavy casing, 10-inch inside diameter, is driven to prevent caving of the hole near the collar. The length of casing depends upon the looseness of the material being drilled. Usually the casing varies from 6 to 8 feet in ordinary ground, but at times 20 feet of casing may be required. The churn-drill holes are spotted by the pit foreman. Two rows of holes are drilled parallel to the crest of the previous cut. The holes in each row of holes are spaced 15 feet apart. The rows of holes are spaced at 12 to 18 feet, depending upon the character of the ground to be drilled and whether the lower bench face has been cleared of broken material. If the lower bench face is covered with material, the row of holes nearest the crest or face of the previous cut is brought closer to the face than usual. The drilling speed of the 42-T churn drills varies from 6 to 12 feet per hour. All benches are 30 feet deep. The holes are drilled 37 feet deep. Water is added during the drilling as needed to supply the cuttings with enough fluid for good bailing and sampling. Overall cost for drilling is $0.90 per foot. There are two men to a drill crew. The 10-inch casing pipes are salvaged for reuse as the blasted material is removed.

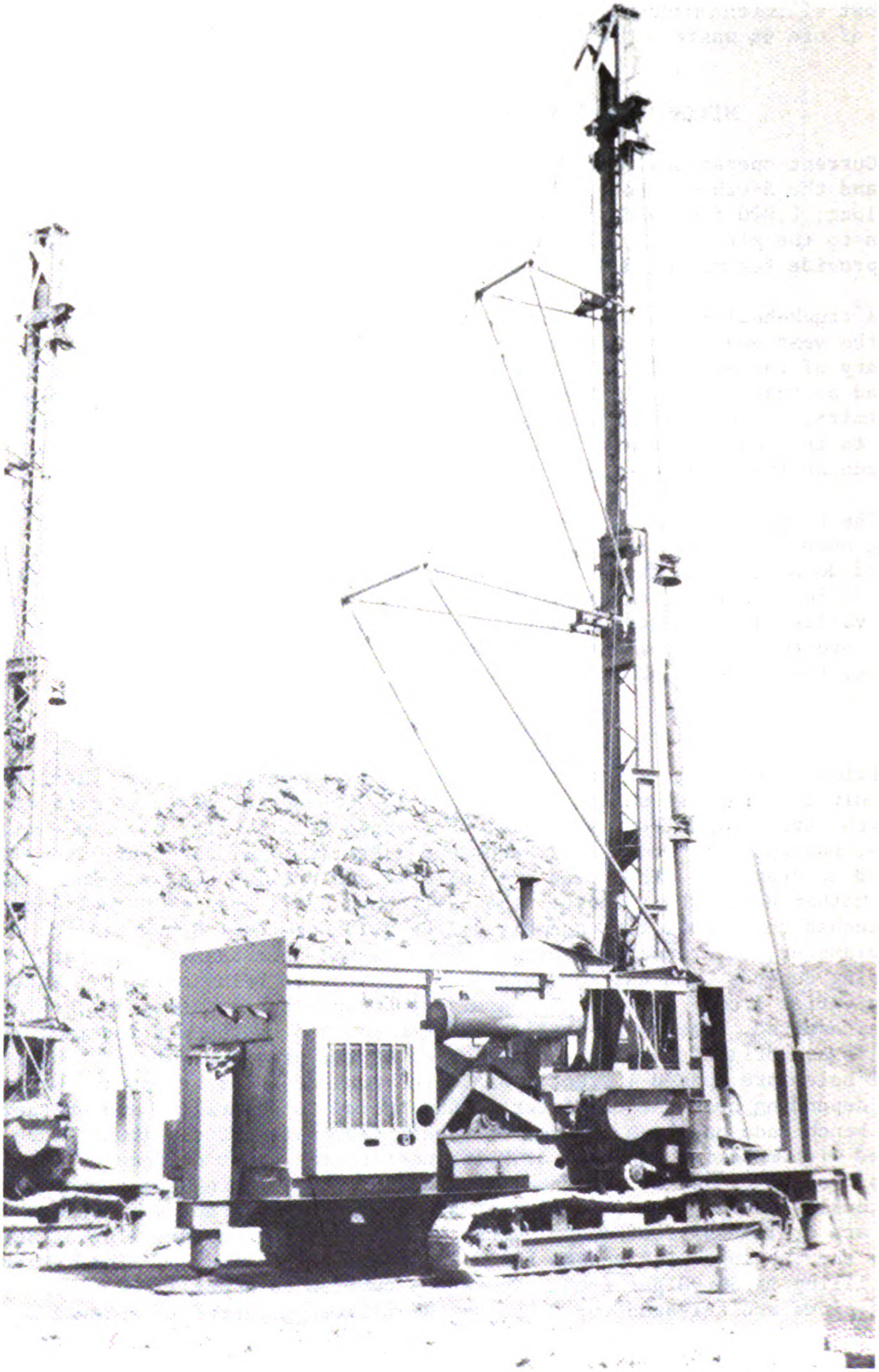


Figure 6. - Bucyrus-Erie churn drill.

crusher to handle maximum tonnage with minimum hauling, to dispose of the waste in the most efficient manner, to mine ore, to make certain grades, and to know the ratio of ore to waste. The last is essential in determining the cost per ton of ore mined.

MINING PLAN FOR NORTH ORE BODY AND SOUTH ORE BODY

Current operations begun in 1952, are on two ore bodies known as the North Ore Body and the South Ore Body, which will be mined in one pit. The pit will be 4,600 feet long, 2,000 feet wide at the widest point, and 660 feet from the highest elevation to the pit floor. It will have 22 benches, each 30 feet high. These benches will provide for mining and stripping the two ore bodies.

A truck-haul road 70 feet wide was constructed on a 7-1/2- to 8-percent grade from the west end of the pit to the top bench elevation at 1,710 feet on the north boundary of the North-South pit (fig. 2). In laying out the haul road it was planned so that the top 10 benches would intersect the bench elevation within the pit limits. Three benches will be mined simultaneously, and work on each will be timed to the requirements of ore and the need for stripping. Work on each bench is begun at the intersection of the road and the bench elevation.

The primary crusher is set at the 1,500-foot elevation, which will permit mining over 15 million tons of ore before moving to a lower elevation. Ore is trucked down grade to the crusher, and waste is either trucked down grade to waste dumps or level across benches to the footwall dump. Length of haul for ore and waste varies from 500 feet to 2,600 feet. The ratio of ore to stripping will be 1 ton of ore to 0.385 cubic yard of waste. At present, ore is being removed from 3 benches, the 1,590, 1,620, and 1,650.

DRILLING

Primary drilling, which represents almost 100 percent of all blast-hole drilling (only 25 boulders usually blasted per 14,000 tons of ore), is done mostly with 6 Bucyrus-Erie, diesel-driven, model 42-T churn drills (fig. 6). Two smaller churn drills, Bucyrus-Erie model 29-T, are used at times. All churn-drilling machines are mounted on crawlers. The holes are collared and drilled with a 9-inch, California-type, Mother Hubbard drill bit. The 42-T churn drill uses a 30-foot stem. When it is attached to the bit the assembly weighs 5,100 pounds. Heavy casing, 10-inch inside diameter, is driven to prevent caving of the hole near the collar. The length of casing depends upon the looseness of the material being drilled. Usually the casing varies from 6 to 8 feet in ordinary ground, but at times 20 feet of casing may be required. The churn-drill holes are spotted by the pit foreman. Two rows of holes are drilled parallel to the crest of the previous cut. The holes in each row of holes are spaced 15 feet apart. The rows of holes are spaced at 12 to 18 feet, depending upon the character of the ground to be drilled and whether the lower bench face has been cleared of broken material. If the lower bench face is covered with material, the row of holes nearest the crest or face of the previous cut is brought closer to the face than usual. The drilling speed of the 42-T churn drills varies from 6 to 12 feet per hour. All benches are 30 feet deep. The holes are drilled 37 feet deep. Water is added during the drilling as needed to supply the cuttings with enough fluid for good bailing and sampling. Overall cost for drilling is $0.90 per foot. There are two men to a drill crew. The 10-inch casing pipes are salvaged for reuse as the blasted material is removed.

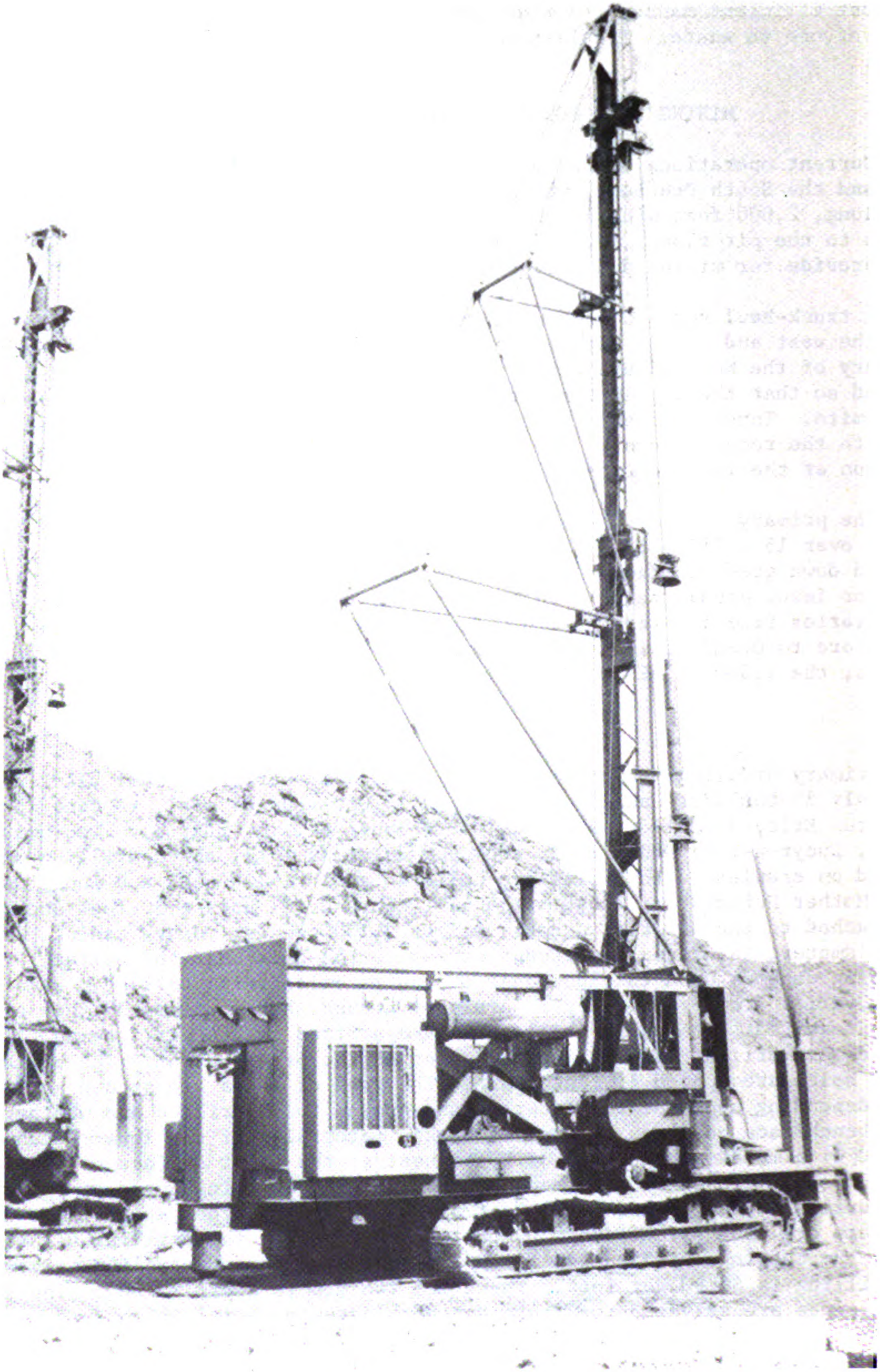


Figure 6. - Bucyrus-Erie churn drill.

Jackhammers and wagon drills are used only when new benches are begun and for roadwork. Jackhammers and jacklegs are also used in drilling boulders preparatory to blasting. As this represents only a limited amount of drilling, portable compressors are used.

BLASTING

The explosives used in blasting the churn-drill holes are 45-percent nitrostarch, slow-speed, bag powder - 6,500 f.p.a. The primer is 75-percent stick powder, which is detonated by electric millisecond delay. Primacord is used when shooting single rows that are not adjacent to high banks.

The blasting foreman checks all holes for water and depth of hole. The dart value bailer is used to clean the hole. The bottom 1-1/2 to 2 feet of hole cannot be cleaned of cuttings; therefore the useful depth of a 37-foot hole is about 35 feet. The first operation in charging the hole is to lower the primer. In dry holes the primer consists of 2-1/2 pounds of 75-percent stick powder containing 2 electric blasting caps. In wet holes the primer consists of 6 pounds of 60-percent gelatin with 2 electric caps. After the primer is placed in the bottom of the hole, 350 to 450 pounds of bag powder is dumped in the hole if in ore. This allows not less than 24 feet of hole for the stemming, which is fine sand rejects from the beneficiation plant dumped at the collar of each hole with a Hydro Payloader. The stemming is not tamped. In a wet hole semigelatin powder in 4- by 24-inch stick form, is placed on top of the primer until the dry portion of the hole is reached; then the bag powder is used, as in a dry hole.

Waste requires 20 to 25 percent less powder than holes in ore. Explosives consumed in 1 year in both ore and waste averages 0.372 pound per ton of material broken. Secondary blasting, amounting to about 25 boulders in 14,000 tons, is done with stick dynamite and No. 6 electric blasting caps.

LOADING

The ore is loaded with four power shovels on crawlers. Two are Bucyrus-Erie, 54-B, diesel-driven shovels with 2-1/2-cubic yard dippers, and two are Bucyrus-Erie electric shovels (one 120-B with a 4-1/2-cubic yard dipper and one 150-B with a 5-cubic yard dipper, fig. 7). About 80 percent of the pit loading is done by electric shovels, assisted by a caterpillar dozer to level and keep truck haulageways clean. Together these shovels can handle 14,000 tons or more per 8-hour shift.

The large shovel operation is normally arranged so that the trucks can be loaded on both sides of the shovel (fig. 8). As one truck is loaded on one side of the shovel, another is in the loading position on the other side of the shovel. This requires a minimum of 80 feet of space to operate with the large shovel and 60 feet with the small shovel. The smaller shovels are ordinarily used to reload stockpiles, in pit areas too narrow for large shovels, and sometimes on road building. A fifth shovel - a 2-1/2-cubic yard, diesel-driven shovel - is used as a spare.

The shovel crew consists of 1 operator and 1 oiler. Electric power is conducted to the shovel by means of a heavy, three-conductor, safety cable which lies on the ground. The precautions taken for safety in the electric shovel operation are described under Safety Organization. Normal loading for a large shovel in ore is about 5,000 tons in an 8-hour shift and 6,500 tons in waste. Small shovels will load 3,500 tons in ore and 4,500 tons in waste.

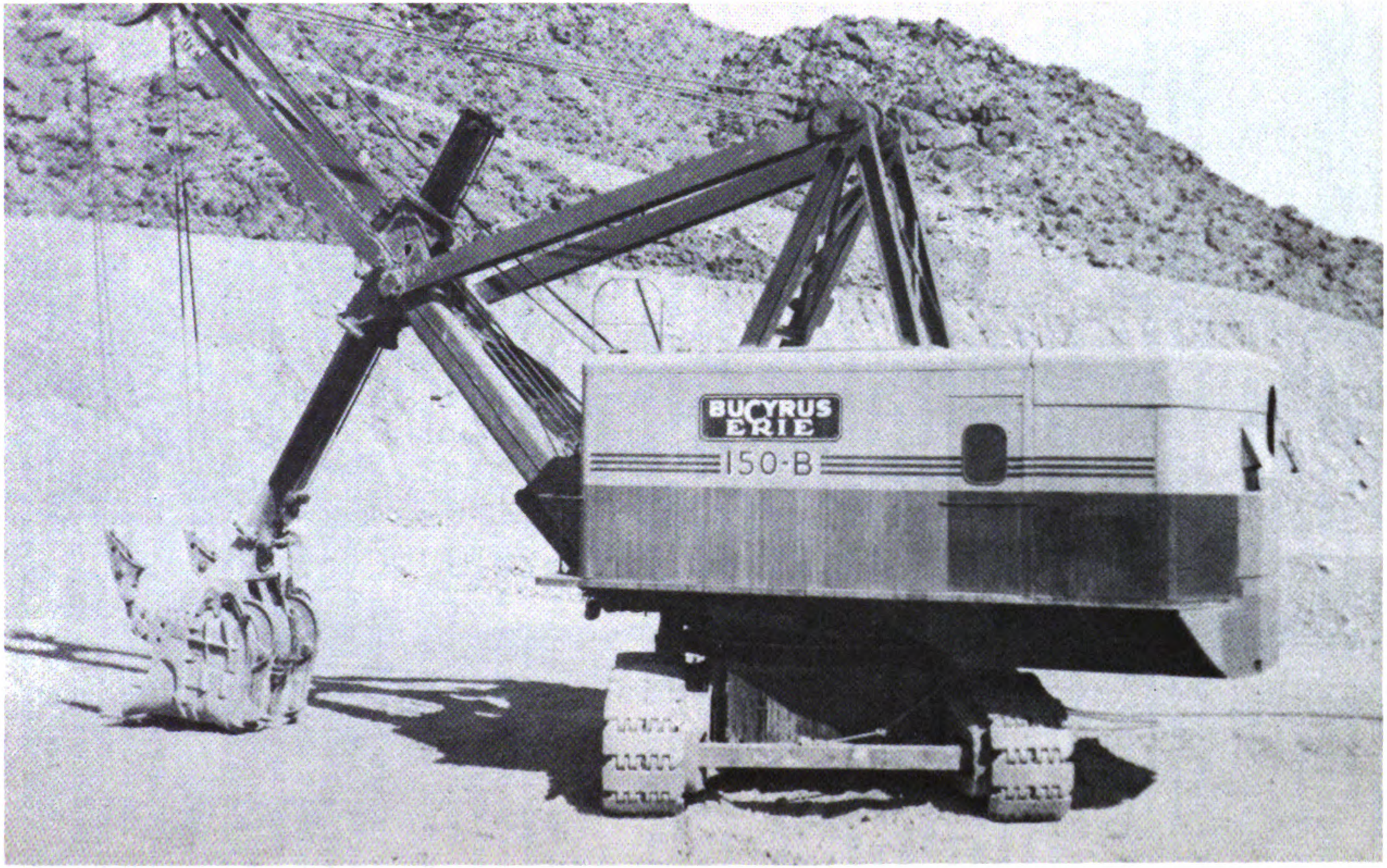


Figure 7. - Bucyrus-Erie 150-B electric shovel.

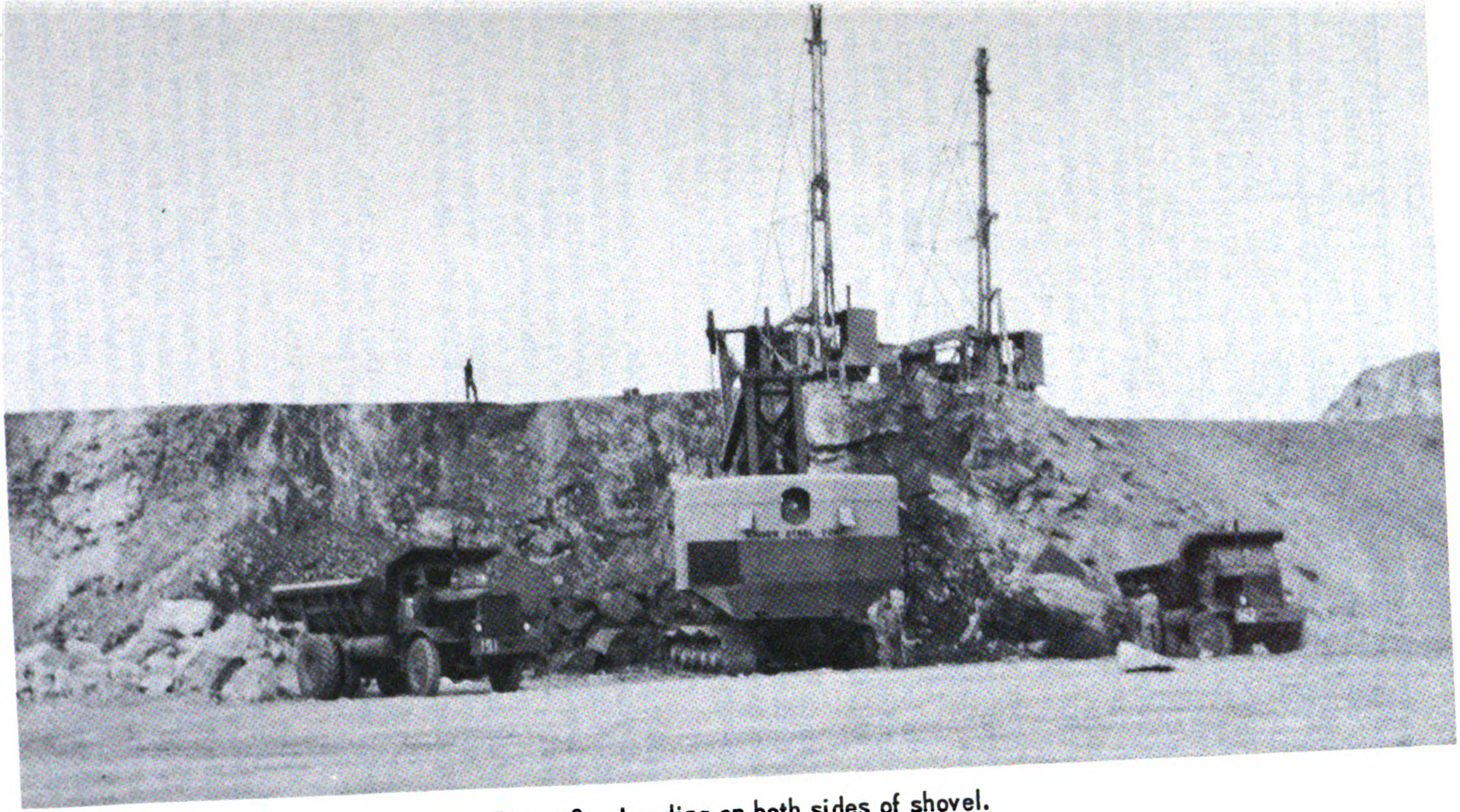


Figure 8. - Loading on both sides of shovel.

TRANSPORTATION

Ore and waste transported by trucks, principally Euclid, type 31, TD, diesel-driven units of 15-cubic yard capacity and Mack L. V. trucks of 15-cubic yard capacity, which replace the smaller type 27, FD Euclid now used only in emergency. Twenty trucks are available, but an average of 18 trucks works on a single-shift basis. Ten trucks are 15-cubic yard Euclids, 3 are 15-cubic yard Macks, and 7 are 10-cubic yard Euclids of the 2-axle, end-dump type. One Euclid, type 31, TD truck has an automatic transmission with two speeds - high and low. With the exception of this truck, all are equipped with Parkersburg Rig & Reel Co., 15-inch Hydrotarders mounted on the drive shaft between the 2 universal joints. A separate water system, including a 115-gallon steamoff tank, is mounted parallel to the truck frame. Power for the system pressure pump is taken off the drive shaft, and the control mounted on the dash is connected by linkage to the three-way valve. Truck speeds can be held to a safe 9 to 15 m.p.h. on 8-percent grades. Use of regular truck brakes is held to a minimum, and relines are required only after 3 to 4 years of service.

A different braking device is used on the Euclid, type 31, TD equipped with the Allison automatic transmission. The braking device is the new, in-the-drive-line Allison Torqmatic brake. The system uses oil for the braking fluid rather than water, as is used in the Parkersburg brake. The pumping action of the rotor circulates the oil to the heat exchanger. Here the water in the motor-cooling system dissipates the heat in the heat exchanger. With this system, the life of the service brakes is increased tremendously.

Experiments were made with various types of liners to protect the truck bodies. The most satisfactory and economical liner was found to be the A-R plate. In May 1952, 5 trucks were lined with A-R plate, a 1-inch, abrasive-resisting, steel plate having a 3-percent manganese content. The installation is rapid, and maintenance has been small.

The roads in the pits are 70 feet wide, and, although not hard surfaced, they are like a pavement. They are kept to grades of 8 percent or under with minimum radii of 150 feet on curves that have a superelevation of about 0.8 foot per 10 feet. The roads are sprinkled continuously, and a power blader is used daily to maintain smooth, dustless surfaces giving minimum tire wear.

Lengths of hauls vary from 500 to 2,600 feet. Truck speed is kept to about 15 m.p.h., loaded. Average per shift for a truck is about 900 tons of mixed ore and waste hauling.

At waste dumps a dumpman directs dumping, and at both waste dumps and shovel cuts the surfaces are leveled with Caterpillar dozers.

COST DATA

Operators are interested in production-cost figures. Table 2 shows the direct operating costs of the 3 major open-pit operations described above for a 12-month period. Since individual company accounting methods and locations vary, overhead, property taxes, interest, depreciation, and depletion costs have not been included; only direct cost for labor, maintenance repairs, and operating supplies per ton of crude ore mined are included. The costs shown are for a single shift working 21 days per month and producing 15,587 tons per day. There were 1,808,000 tons of ore and 2,120,000 tons of waste, a total of 3,928,000 tons worked during the month; a ratio of ore to waste of 1 to 1.73. The average truck haul was 1,800 feet.

TABLE 2. - Operating costs of major pit operations

	Costs per ton of crude ore mined				
	Labor[1/]	Repairs	Supplies	Special items	Total
				(Explosives)	
Drilling and blasting ..	$0.04	$0.01	$0.02	$0.06	$0.13
Shovel operation	.01	.02	.01	0	.04
				(Tires)	
Truck operation	.02	.02	.01	.01	.06
Total	$ .07	$ .05	$ .04	$ .07	$ .23

[1/] Cost includes direct supervision, payroll tax, and insurance.

Ratio of ore to waste 1 to 1.173

Hourly wage rates paid for main job classifications are shown in table 3.

TABLE 3. - Wage rates of main job classification

Job classification	Hourly rate
Laborer	$1.85
Drillers:	
Jackhammer	2.00
Wagon drill	2.15
Churn drill	2.25
Heavy-duty truck driver	2.20
Mechanic's helper	2.00
Mechanic	2.35
Shovel operator	2.55

The organization personnel at the mine includes a general pit foreman, who is responsible for drilling, blasting, shovel, and trucking operations; a general foreman at the beneficiation plant, who is responsible for crushing, beneficiation, and ore shipping; a general foreman (railroad), who is responsible for train operation and maintenance of way; a master mechanic, who is responsible for maintenance of equipment and facilities (electrical and mechanical); a mine engineer, who is responsible for all engineering; and an office manager, who is responsible for accounting, payrolls, warehouse, and company store operation.

CRUSHING AND LOADING

At the 1,500-foot elevation in the North-South pit trucks dump into a 50-ton hopper (fig. 9) feeding directly into a 66- by 84-inch jaw crusher set to 7-1/2 inches (fig. 10). The crushed ore is transferred to a surge pile on a 60-inch belt conveyor. The surge pile has a capacity of 56,000 tons, of which 5,000 tons are considered live storage. In an emergency the balance of the surge pile could be moved into the drawpoint by bulldozers. From the surge pile the ore is drawn off through an underground reclaiming tunnel controlled at drawpoint by a 60-inch pan feeder discharging into a rock box on a 42-inch belt conveyor to the secondary crushing unit giving a 3-inch product. This product is taken to a third crusher in closed circuit with sizing screens to give a final product of minus-1-inch.

Provisions has been made to treat this material in a beneficiation plant (figs. 11 and 12), which is under construction. The process will be magnetic separation and heavy medium separation.

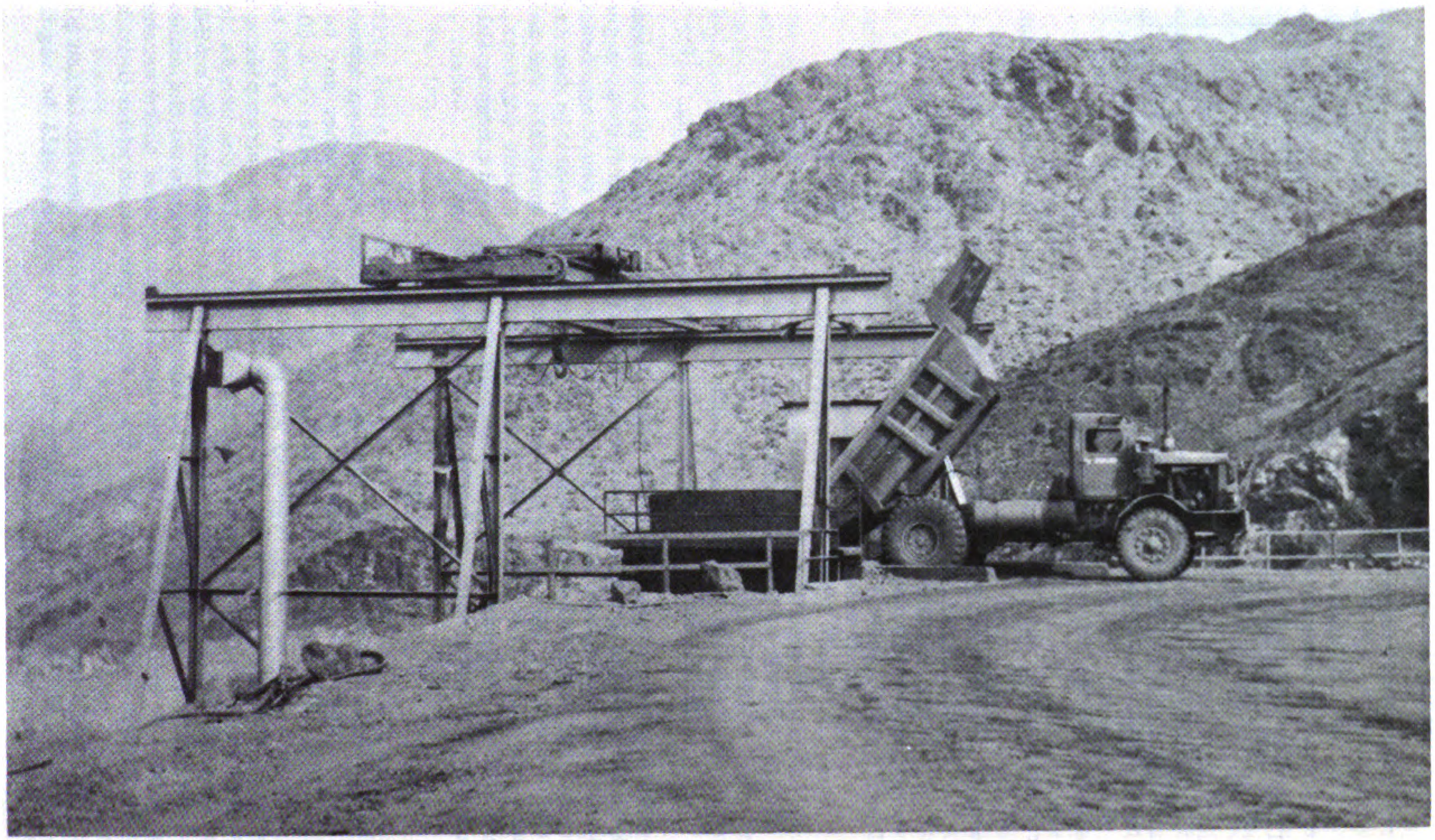


Figure 9. - Truck dumping into primary crusher.

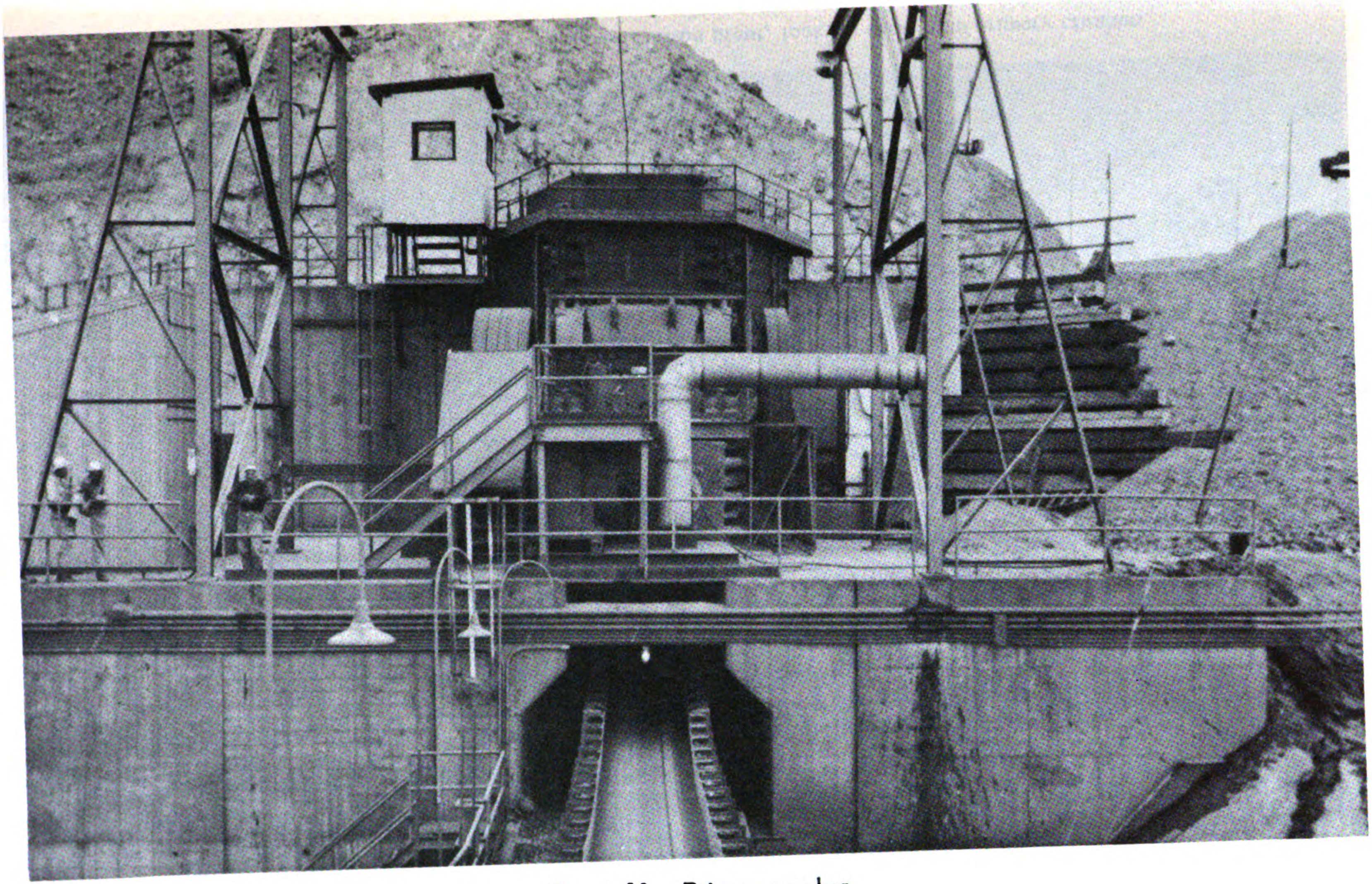


Figure 10. - Primary crusher.

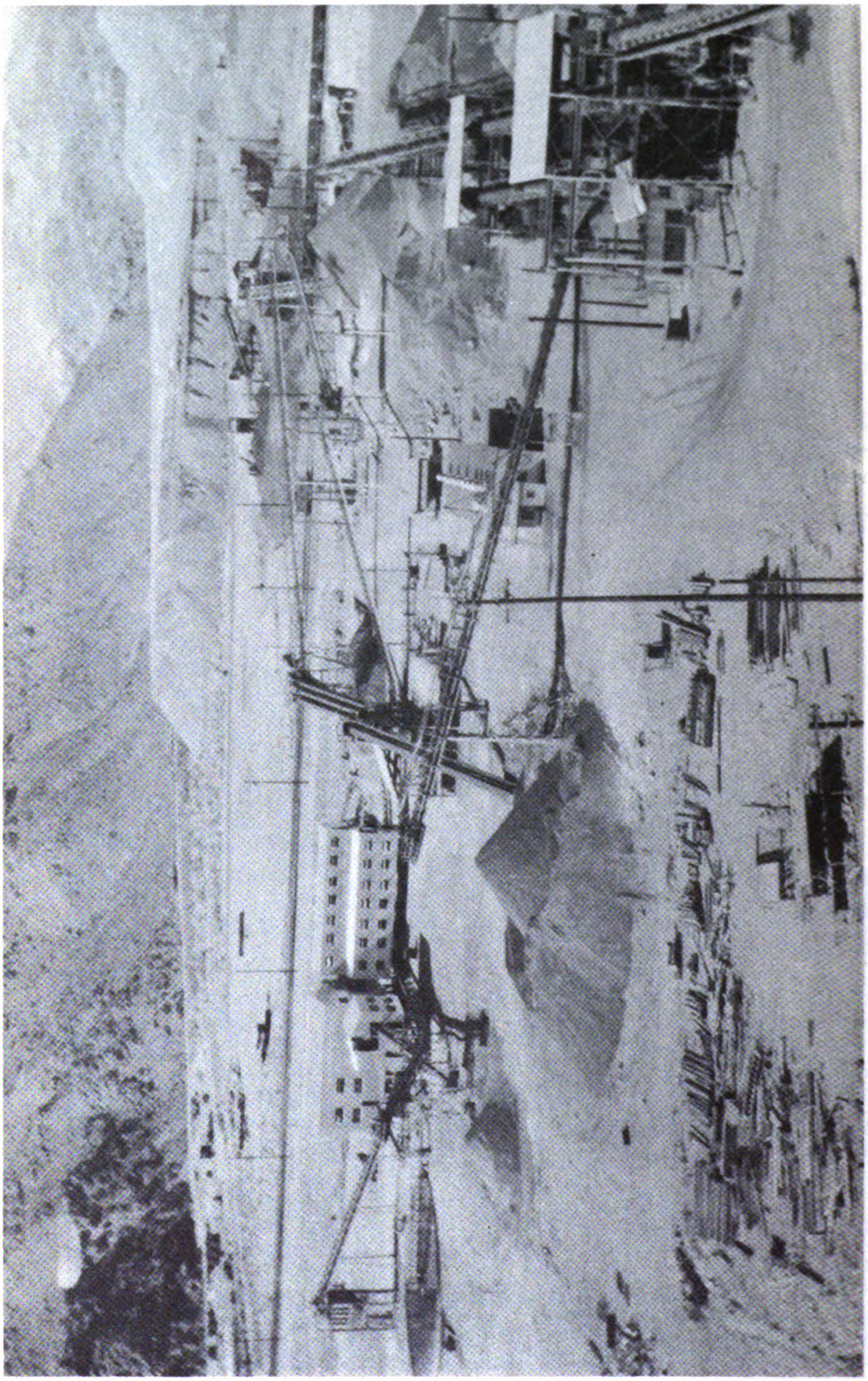


Figure 11. - Secondary crusher and beneficiation plant, looking west from primary crusher.

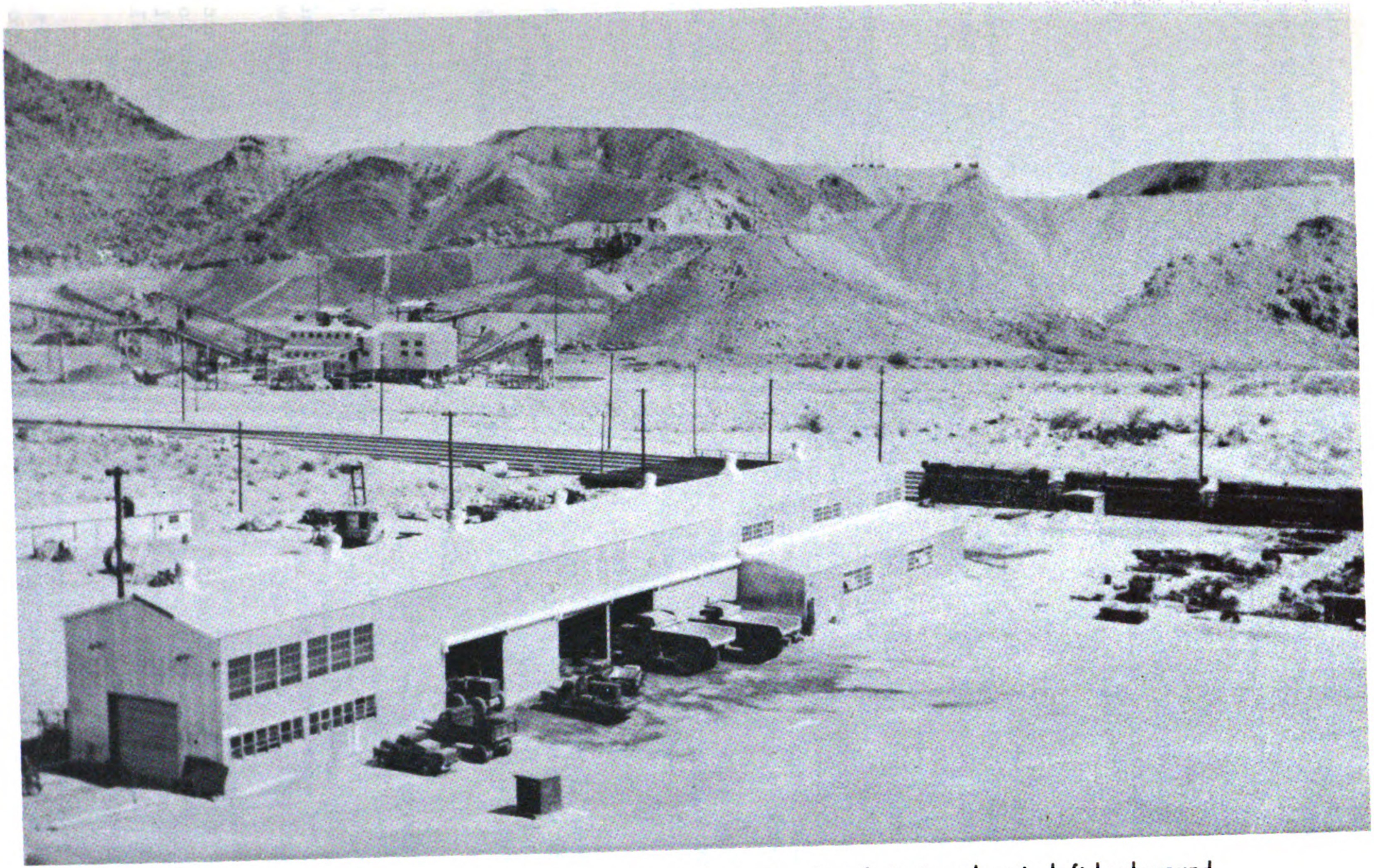


Figure 12. - View looking east toward North and South pits; beneficiation plant in left background.

The shipping grades of ore are conveyed to stockpiles east of the loading tower. The ore is drawn off from a reclaiming tunnel underneath the stockpiles. It is controlled at the drawpoints by chute gates discharging on to a 42-inch conveyor belt. This ore dumps into an ore bin over a railroad scale (fig. 13). The belt and scale are operated by a weighmaster from a control tower near the truck.

SAMPLING

The churn-drill holes for blasting are sampled every 10 feet in ore. These analyses control the grade of the ore mined daily. The railroad cars are sampled at the Kaiser Steel Corp. plant at Fontana, Calif.

RAILROAD OPERATION

In 1946 and 1947 Kaiser Steel Corp. had a standard-gage railroad constructed under contract to connect the mine with the Southern Pacific Railroad at Ferrum, Calif., about 52 miles away. Ferrum is southwest of the mine and lies near the Salton Sea.

The railroad is a part of the overall mine operation. Four 1,600-horsepower, 150-ton, Baldwin, diesel-electric locomotives serve as power units for hauling 90 to 110 cars per day. The Southern Pacific Railroad supplies steel, gondola-type railroad cars of 62.5-ton capacity. Each round trip requires 7 to 9 hours. When the 3 blast furnaces at Fontana are in full production, 2 round trips per day of 70 cars each handle the required daily tonnage.

Ruling grade against the loads is 1.0 percent compensated; and is 2.15 percent compensated against the empties. Locomotives are equipped for multiple-unit operation and with electro-dynamic braking for the excessive grade.

DRAINAGE, WATER SUPPLY, POWER

Because of the topography there is no drainage problem in the open pit, and pumping is not required. Water is obtained from a well 9 miles by road north of the pit, pumped into tanks, and fed by gravity to the camp and pit. Power is obtained from the California Electric Power Co.

SAFETY ORGANIZATION

The safety engineer at the Fontana Steel plant visits the Eagle Mountain property monthly. The assistant superintendent conducts monthly safety meetings; all employees, including the mine superintendent and a safety supervisor, attend. Various safety topics are discussed, and the employees are requested to bring unsafe practices and unsafe conditions to the attention of the management. The various foremen hold safety meetings with their crews.

The foreman makes a written report on all accidents. The more serious accidents are investigated by a safety committee. They place the responsibility for the accident and decide on preventive measures to be taken and the proper disciplining of those considered responsible for the accident. The machinery is well guarded. Safety regulations, such as wearing hard hats, goggles, respirators, and hard-toed shoes, are enforced.

Safety bulletins obtained from the National Safety Council, the State Division of Industrial Safety, and the Industrial Indemnity Insurance Co. and special posters

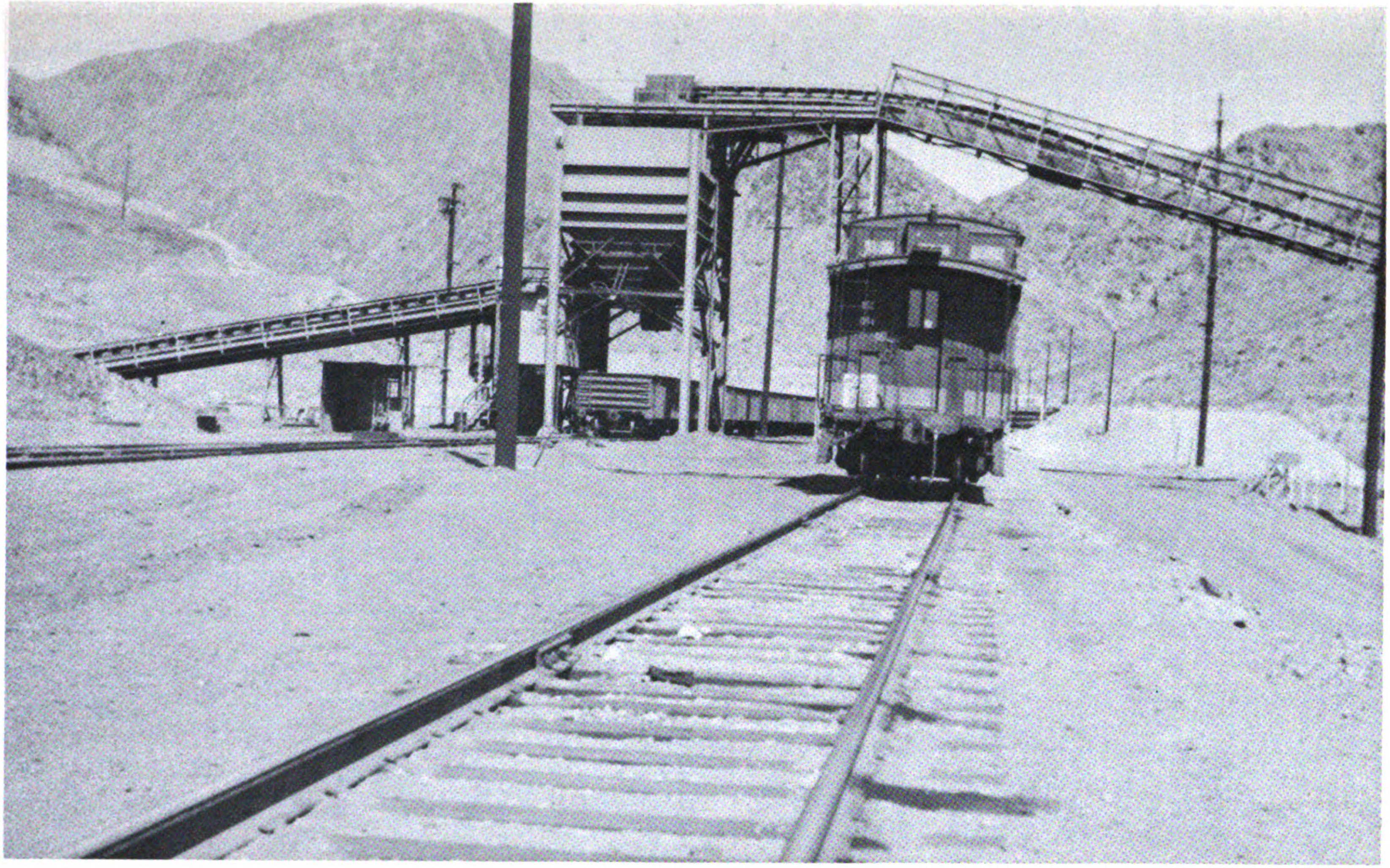


Figure 13. - Loading tower.

from the Elliot Service and others are displayed on safety bulletin boards in various departments. The safety bulletin board at the mine office shows the number of accidents each month, also the number of days without a lost-time accident (fig. 14).

Safety is stressed throughout the operation and particularly in electric-shovel operations. Each shovel circuit has a skid-mounted safety breaker. Power for the shovel passes through the breakers, and the shielded ground wire of the cable connects through a relay in the safety breaker box. A resistance to ground, which limits the current to from 15 to 20 amp., actuates the relay and opens the breaker switch, instantly cutting all power to the shovel. The breakers have justified their use on several occasions.

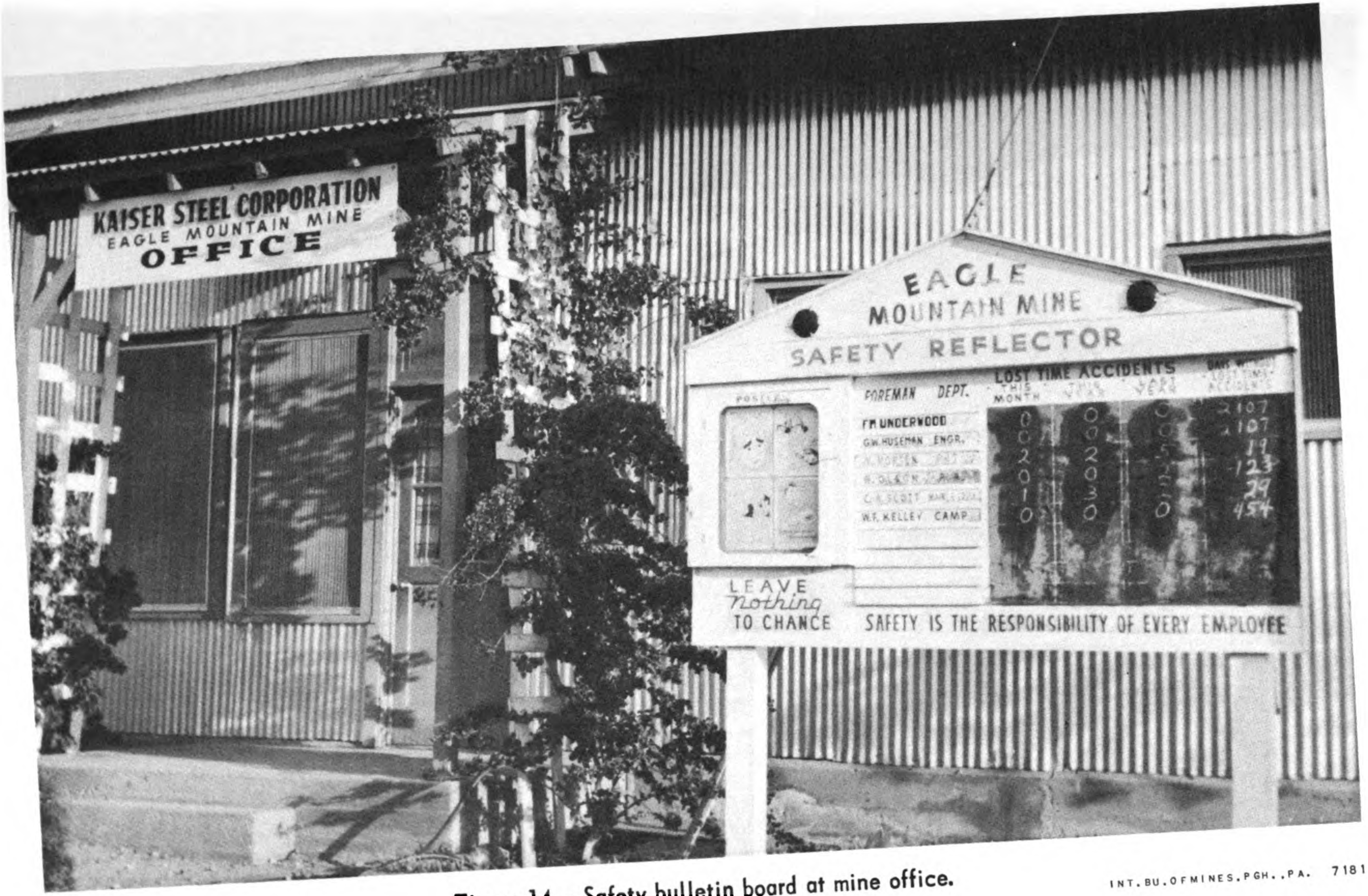
An overhead ground wire is carried as a fourth wire throughout the pit power-distribution system. A connection from the ground wire is carried to each of the power connection points together with the power wires. At all connection points, the power circuit passes through fused breakers and the ground wire is lugged for ease in connecting the power cable leads. The overhead ground wire, as mounted on top of the power poles, serves as a lightning arrestor.

The power-distribution system, serving the entire operation, has an additional safety factor. The system is divided into six separated sections by general areas served such as houses, shops, crushers, and pits. Built into each of these systems and located in the switching station are grounded transformers of the latest design. A ground in any section will instantly open breaker to the section and deenergize it. The State Industrial Accident Commission has complimented the operators for installing sectionalized ground protection. By sectionalizing the system, in case of failure by grounding only a small portion of the operation is effected.

For night operation, the pit roads are well lighted by flood lights mounted on high poles. Floodlights are installed on all shovels and also on the churn drills.

Employees volunteer for first-aid training given by the Bureau of Mines. As a result of the interest in safety from the top management down, the Kaiser Steel Corp. safety record for 1953, when compared with the safety record of the Nation's open-pit operations, is very good. The comparison is as follows:

	Kaiser Steel Corp.	National
Frequency rate	20.4	33.6
Severity rate	.1	4.02



INT. BU. OF MINES, PGH., PA. 7181

Figure 14. - Safety bulletin board at mine office.